Problems and Problem Solving

Course: CSE 1100- Introduction to Computing

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What is a Problem?

- "A problem exists when there is a discrepancy between an initial state and a goal state, and there is no ready-made solution for the problem solver.“ (Taken from book ‘The Ideal Problem Solver’, p.20

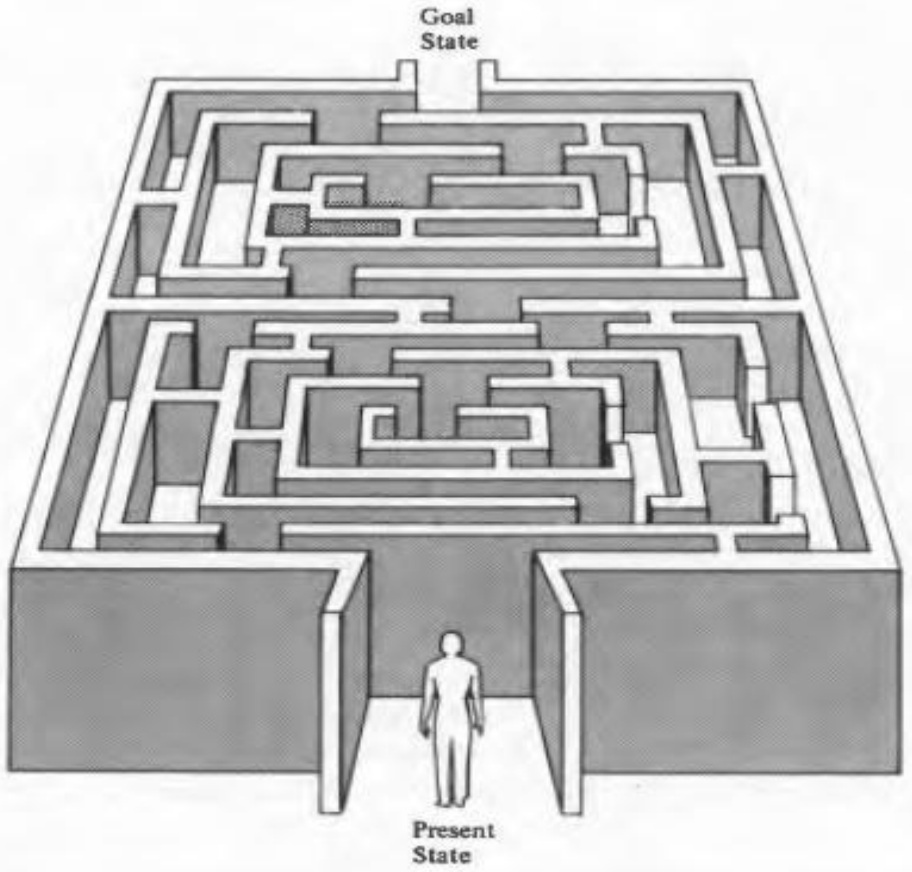


Figure 2 A problem exists when an obstacle separates the present state from the goal state.

What is a Problem?

Difference/discrepancy between – a present situation/what is observed (**what is**) and a desirable outcome/ ideal or what is expected (**what we want**)

Types of Problems

Type of Problem	Well structured problems	Moderately structured problems	Ill structured problems
Definition	Problems that always use the same step-by-step solution.	Problems that require varying strategies and adaptations to fit particular contexts.	Problems with vague and unclear goals. Solution strategies least constrained.
Characteristics	• Solution strategy is usually predictable • Convergent (one right answer) • All starting information is usually part of the problem statement.	• Often more than one acceptable solution strategy. • Convergent (one right answer). • Needed information often must be gathered.	• Solution is not well defined or predictable. Multiple perspectives, goals, and solutions. • There is no single well-defined and agreed-upon solution; there may not be a fully satisfactory solution at all. • Needed information often must be gathered.
Examples	Balancing a checkbook, following a recipe, and solving a crossword puzzle	Designing a spreadsheet, writing a letter, and planning a sales call	Painting a portrait, designing a bridge, and creating a new computer program

Types of Problems

- Problems for which solutions are unknown
- Problems for which solutions are known, but the best solution is not obvious
- Problems where the cause is unknown and must be discovered
- Problems where the cause is known, or is known and irrelevant
- Solutions are known, but best solution is not obvious
  - Solutions with certain outcomes
  - Solutions with uncertain outcomes
  - Solutions in need of being prioritized

Types of Problems

- **Tame Problems**
  - can be solved in a linear fashion using straightforward, reductionist, repeatable, sequential techniques

- **Complex Problems**
  - tend to be non-linear, difficult to understand and their solutions can lead to other problems and unintended consequences.

- **Wicked Problems**
  - hardest to solve and have an overlap with Complex problems.
  - goals are either not known or ambiguous, and means-ends relationships are poorly understood.

http://www.drbrd.com/problems_and_solutions/three_types_of_problems.html

What is Problem Solving ?

Problem Solving *is the sequential process of analyzing information related to a given situation and generating appropriate response options.*

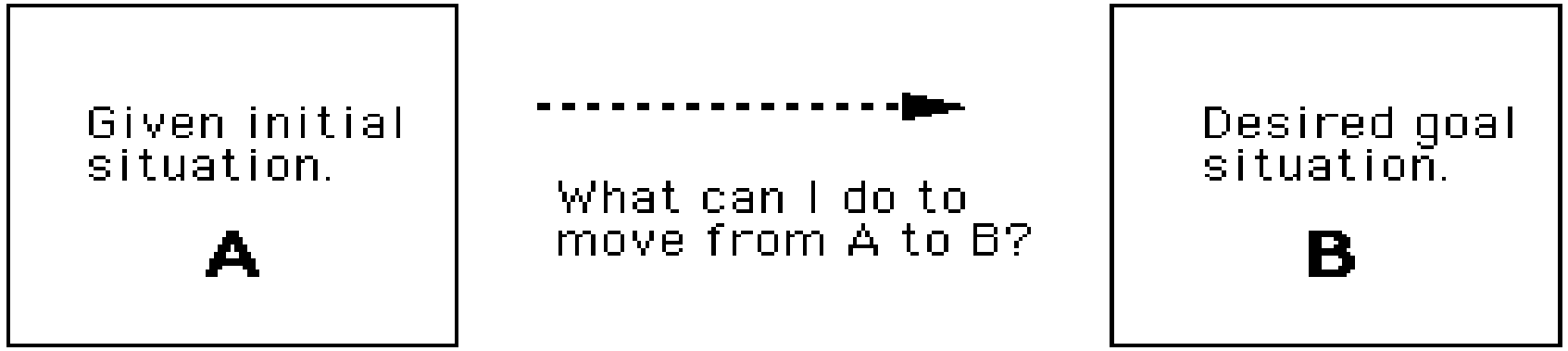


Figure 1.1 Problem-solving process--from initial situation to final goal.

What is Problem Solving ?

Some initial questions:

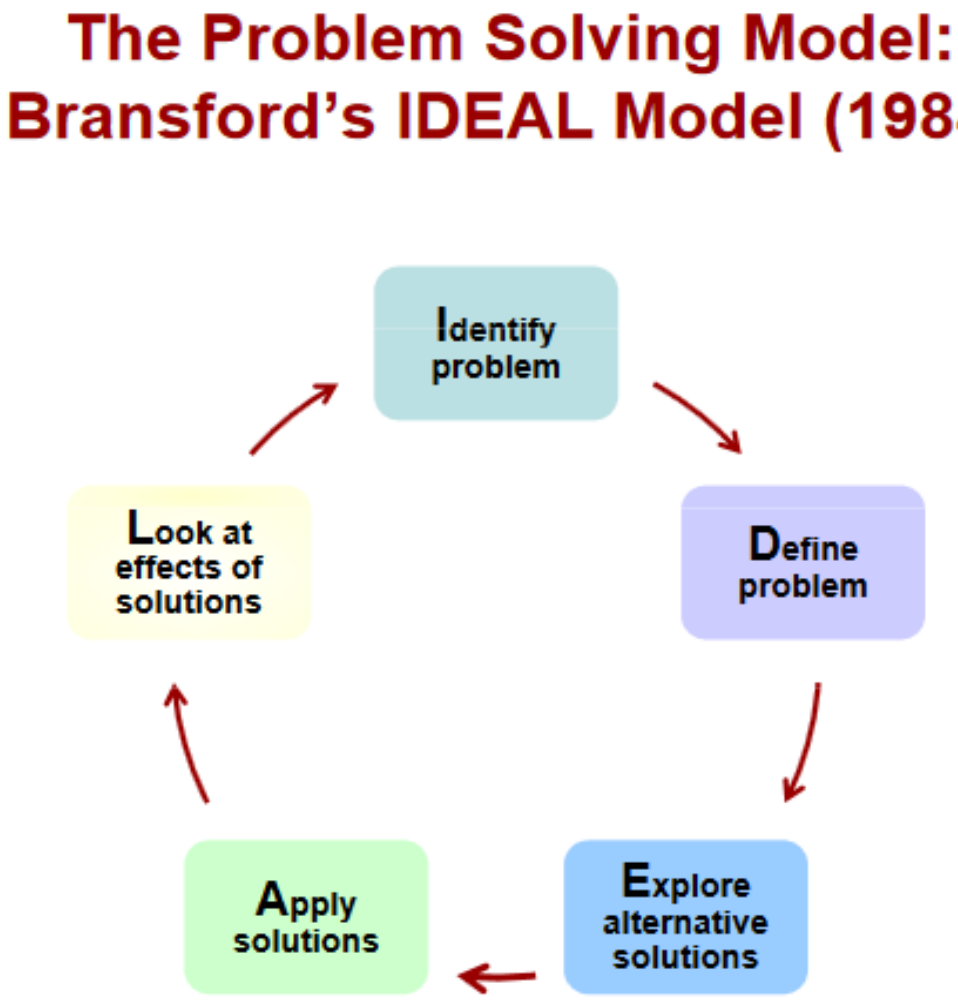
1. Is there a clearly defined given initial situation? (Do I really know the facts?)

2. Is there a clearly defined goal? (Is it really clear to me how I would like things to be?)

3. Do I know what resources are available to me that I could use to help achieve the goal? In addition, are there rules, regulations, and guidelines that I need to know about as I work to solve this problem?

4. Do I have ownership--do I care enough to devote some of my own resources? (Am I willing to spend some time on achieving the goal?)

Problem Solving Models/Processes



Problem Solving Models/Processes

- Newell & Simon (1972) - think of problem solving in terms of input, process and output, then:

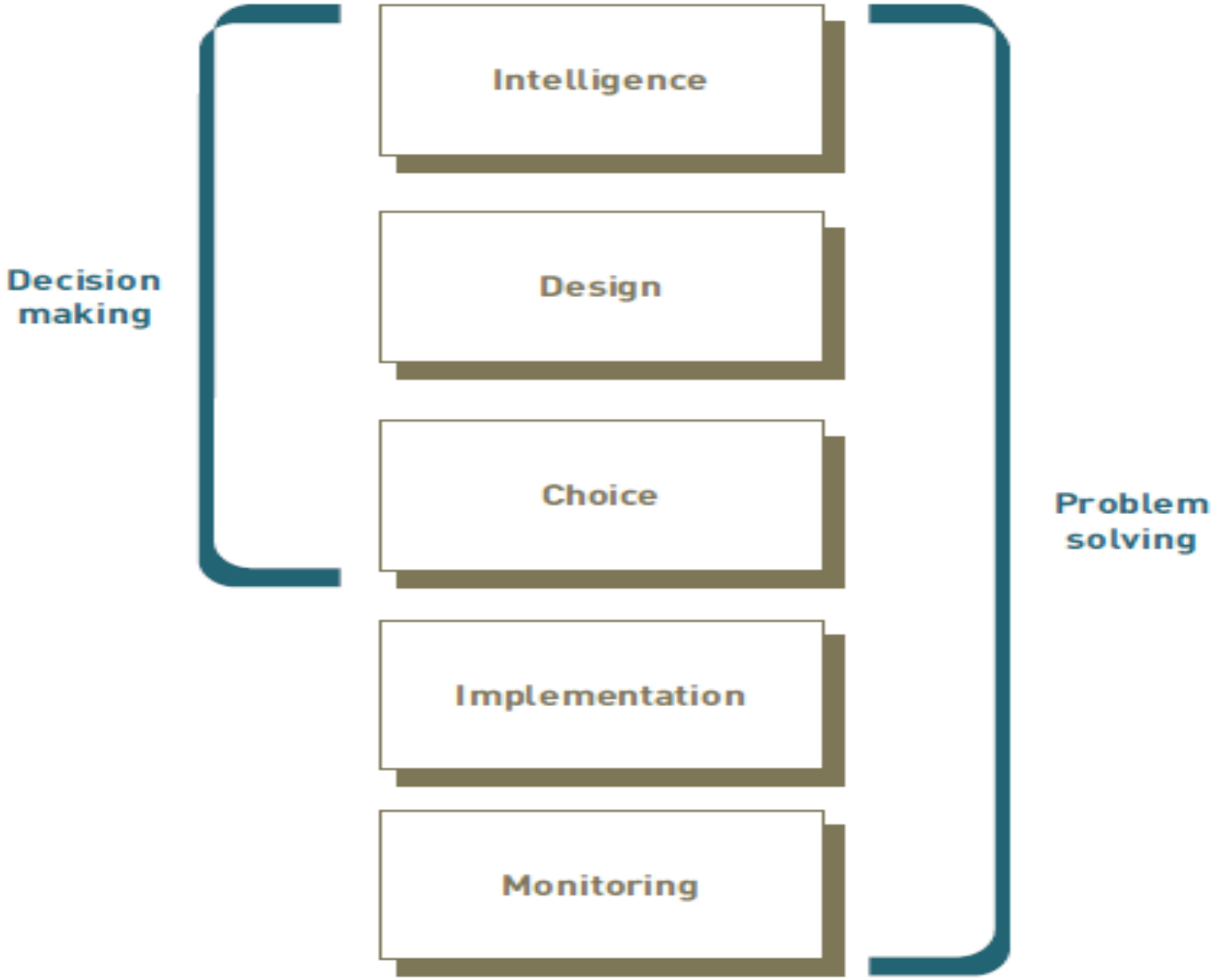
- *Well structured* problems typically have well-defined inputs, processes and outputs.

- *Moderately structured* problems typically have well-defined inputs, a range of alternative processes, and a range of outputs. The processes and outputs typically include some that are clearly “wrong” and a number which are potentially “right” solutions.

- *Loosely structured* problems typically have little definition of inputs, processes and outputs.

Decision Making & Problem Solving

- George Huber model of PS



Decision Making & Problem Solving

Decision Making is a step in problem solving

- **Intelligence gathering**
  - Definition of problem (or opportunities)
  - Data gathered on scope
  - Constraints identified
- **Design phase**
  - Alternatives identified and assessed
- **Choice**
  - Selection of an alternative

A Model for Problem Solving

- **Decision Making Phase**
  - Intelligence gathering
    - Collect data from inside the organization.
    - Collect data from outside the organization.
    - Collect information on possible ways to solve the problem.
  - Design
    - Organize the data; select a model to process the data.
    - Produce reasonable, potential courses of action.
  - Choice
    - Select a course of action.
- Implementation
- Monitoring

Computational Problem Solving Models/Processes

Problem Solving is a Process.

Depending on which text you read, a number of variants might be noticed. However, problem solving revolves around a number of important steps. Below is one such model:

There are 6 steps that you should follow in order to solve a problem:

1. Understand the Problem
2. Formulate a Model
3. Develop an Algorithm
4. Write the Program
5. Test the Program
6. Evaluate the Solution

Problem Solving Example

A Simple Problem Solving Example

Consider a simple example of how the input/process/output works on a simple problem:

Example: *Calculate the average grade for all students in a class.*

1. **Input**: get all the grades … perhaps by typing them in via the keyboard or by reading them from a USB flash drive or hard disk.

2. **Process**: add them all up and compute the average grade.

3. **Output**: output the answer to either the monitor, to the printer, to the USB flash drive or hard disk … or a combination of any of these devices.

As you can see, the problem is easily solved by simply getting the input, computing something and producing the output. Let us now examine the 6 steps to problems solving within the context of the above example.

Problem Solving Example

STEP 1: Understand the Problem:

It sounds strange, but the first step to solving any problem is to make sure that you understand the problem that you are trying to solve. You need to know:

- What input data/information is available ?
- What does it represent ?
- What format is it in ?
- Is anything missing ?
- Do I have everything that I need ?
- What output information am I trying to produce ?
- What do I want the result to look like … text, a picture, a graph … ?
- What am I going to have to compute ?

In our example, we well understand that the input is a bunch of grades. But we need to understand the **format** of the grades. Each grade might be a **number from 0 to 100** or it may be a **letter grade from A+ to F**. If it is a number, the grade might be a **whole integer** like 73 or it may be a **real number** like 73.42. We need to understand the format of the grades in order to solve the problem.

We also need to consider missing grades. What if we do not have the grade for **every** student (e.g., some were away during the test) ? Do we want to be able to **include** that person in our average (i.e., they received 0) or **ignore** them when computing the average ?

We also need to understand what the output should be. Again, there is a formatting issue. Should we output a **whole** or **real number** or a **letter grade** ? Maybe we want to display a pie chart with the average grade. It is our choice.

Finally, we should understand the kind of processing that needs to be performed on the data. This leads to the next step.

Problem Solving Example

Formulate A Model

STEP 2: Formulate a Model:

Now we need to understand the processing part of the problem. Many problems break down into smaller problems that require some kind of simple mathematical computations in order to process the data. In our example, we are going to compute the average of the incoming grades. So, we need to know the model (or formula) for computing the average of a bunch of numbers. If there is no such "formula", we need to develop one. Often, however, the problem breaks down into simple computations that we well understand. Sometimes, we can look up certain formulas in a book or online if we get stuck.

Problem Solving Example

In order to come up with a model, we need to fully understand the information available to us. Assuming that the input data is a bunch of integers or real numbers $x_1, x_2, \ldots, x_n$ representing a grade percentage, we can use the following computational model:

$$\textbf{Average1} = (x_1 + x_2 + x_3 + \ldots + x_n) / n$$

where the result will be a number from 0 to 100.

That is very straight forward (assuming that we knew the formula for computing the average of a bunch of numbers). However, this approach will not work if the input data is a set of letter grades like **B-, C, A+, F, D-**, etc.. because we cannot perform addition and division on the letters. This problem solving step must figure out a way to produce an average from such letters. Thinking is required.

After some thought, we may decide to assign an integer number to the incoming letters as follows:

$A^+ = 12$	$B^+ = 9$	$C^+ = 6$	$D^+ = 3$	$F = 0$
$A = 11$	$B = 8$	$C = 5$	$D = 2$	
$A^- = 10$	$B^- = 7$	$C^- = 4$	$D^- = 1$	

If we assume that these newly assigned grade numbers are $y_1, y_2, \ldots, y_n$, then we can use the following computational model:

$$\textbf{Average2} = (y_1 + y_2 + y_3 + \ldots + y_n) / n$$

where the result will be a number from 0 to 12.

Problem Solving Example

As for the output, if we want it as a percentage, then we can use either **Average1** directly or use **(Average2 / 12)**, depending on the input that we had originally. If we wanted a letter grade as output, then we would have to use **(Average1/100*12)** or **(Average1*0.12)** or **Average2** and then map that to some kind of "lookup table" that allows us to look up a grade letter according to a number from 0 to 12.

Do you understand this step in the problems solving process ? It is all about figuring out how you will make use of the available data to compute an answer.

End of Lecture!!!